

Development of Environmental Indicators of Biological Integrity for Plant Assemblages of Indiana Lakes



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IBI's

- originally for stream fish assemblages
- rapid, cost-effective, precise, and repeatable
- now IBI's are available for a variety of assemblages and habitats
- but few for primary producers

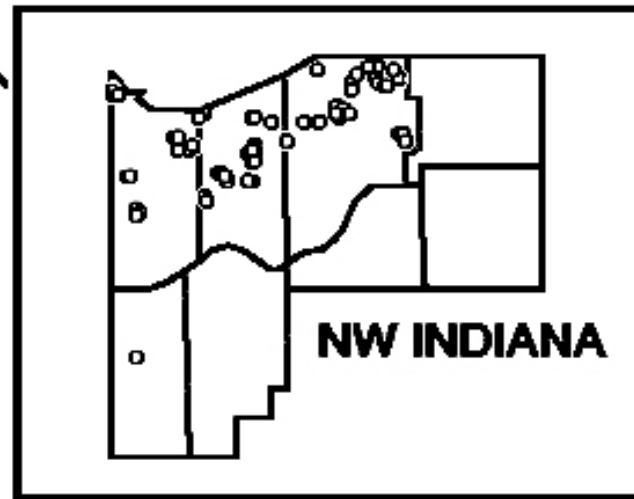
PIBI

- Simon et al (2001) showed the feasibility of PIBI
- Used palustrine and riverine wetlands along south shore of Lake Michigan
- Our current effort is to expand this to lake ecosystems

65 LAKES



90 W
+ 40 N



Broad range of quality
from least affected to
those in residential and
industrial settings

1 to 380 hectares

Initial Assessment of Lake Quality

Two measures were used

Best Professional Judgment
(scale of 0 to 10)

QHEI modified for lake setting



- 1 present

3 rare/common

5 very common

6 abundant

[illegible]

Metrics and Metric Testing

- Over 35 metrics were evaluated
- *A priori* hypotheses were tested via Spearman correlations
- 12 metrics, falling into 4 functional categories, were chosen
- Plotted against lake size to search for possible factor ceiling-distributions

I. Species Richness and Composition

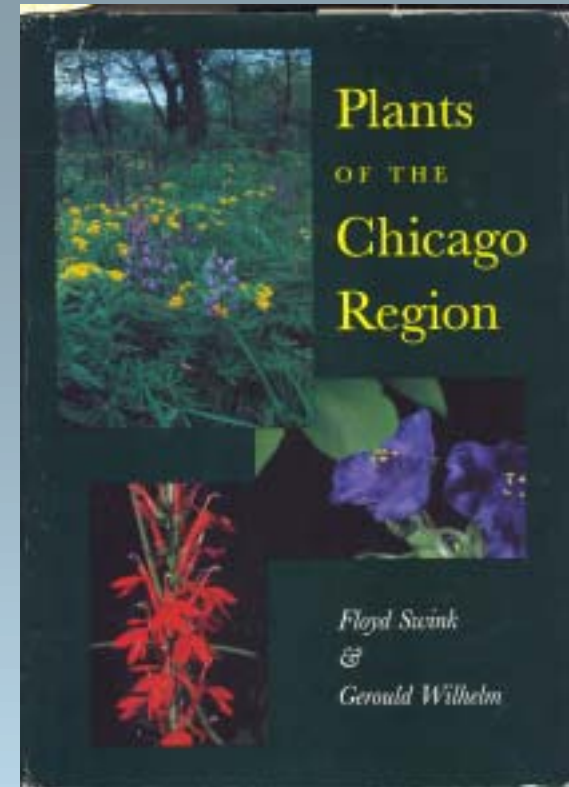
Metric	Hypothesized Change	Quality Measure	r ²	p
1. total number of species	Increase	Ranking	0.35	0.0002
		QHEI	0.49	<0.0001
2. number of submergent species	Increase	Ranking	0.41	<0.0001
		QHEI	0.54	<0.0001
3. number of floating-leaved species	Increase	Ranking	0.27	0.006
		QHEI	0.48	<0.0001
4. number of emergent species	Increase	Ranking	0.32	0.001
		QHEI	0.36	0.0002

II. Species Tolerance

Metric	Hypothesized Change	Quality Measure	r^2	p
1. number of sensitive species	Increase	Ranking	0.69	<0.0001
		QHEI	0.67	<0.0001
2. percent of tolerant and exotic species	Decrease	Ranking	-0.55	<0.0001
		QHEI	-0.47	<0.0001

C-value

- Coefficient of Conservatism
- Applied by Swink and Wilhelm (1994) to all plants species occurring in the overall Chicago region
- Used to determine sensitive species – 8 to 10
- Used to determine tolerant species – 0 to 2



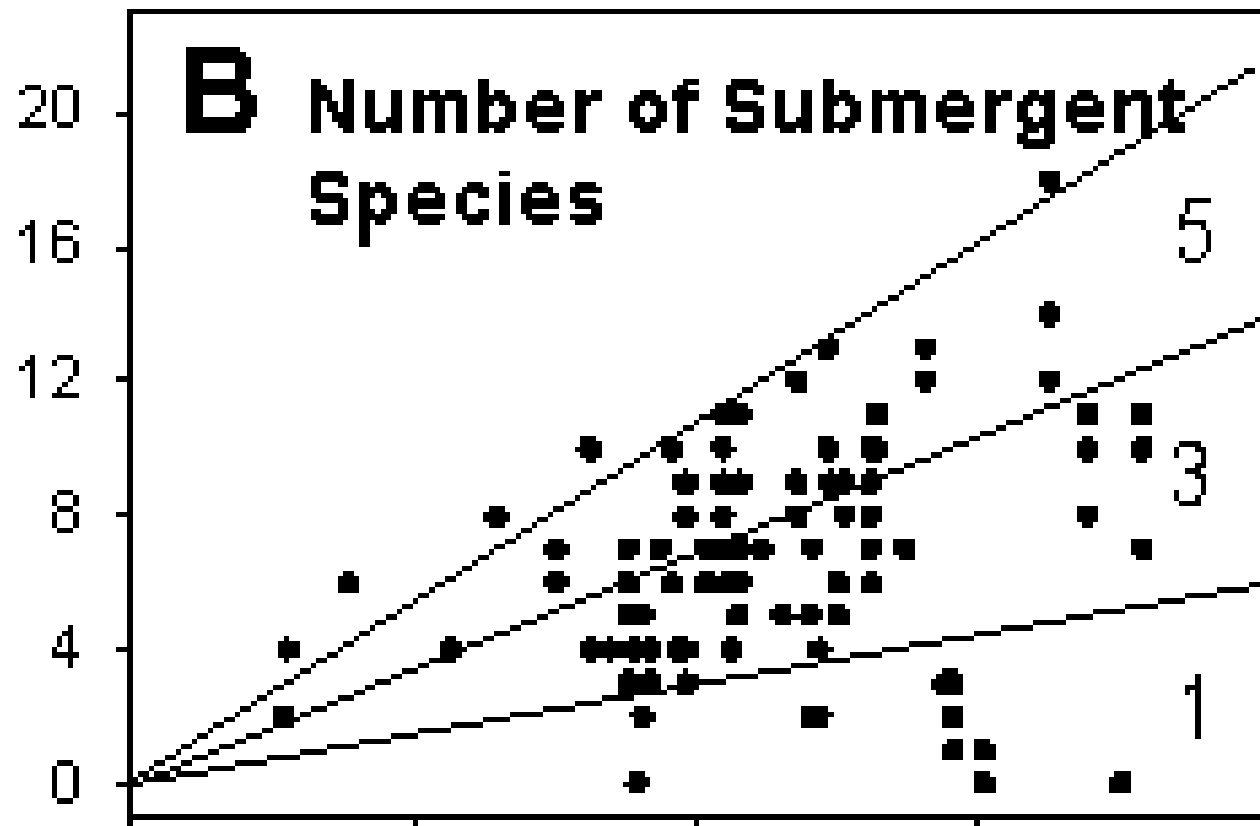
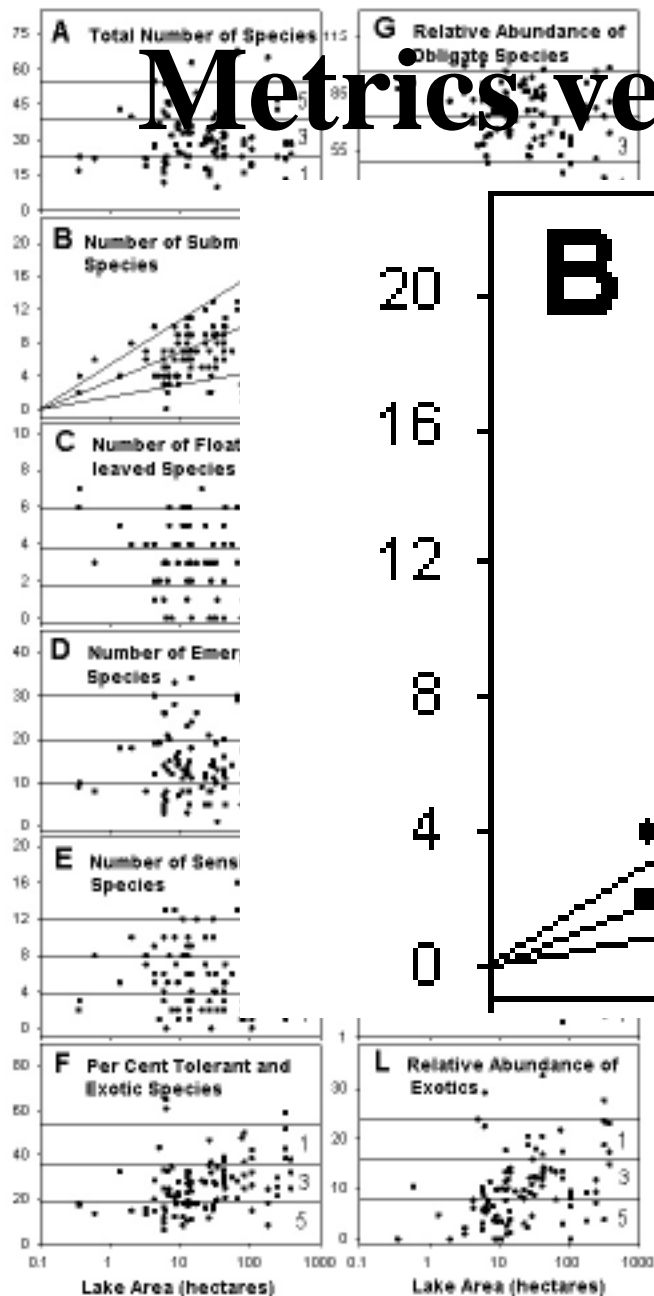
III. Guild Structure

Metric	Hypothesized Change	Quality Measure	r ²	p
1. relative abundance of obligate spp.	Increase	Ranking	0.33	0.0006
		QHEI	0.39	<0.0001
2. relative abundance of sensitive spp.	Increase	Ranking	0.62	<0.0001
		QHEI	0.52	<0.0001
3. relative abundance of tolerant spp.	Decrease	Ranking	-0.54	<0.0001
		QHEI	-0.51	<0.0001
4. relative abundance of woody spp.	Decrease	Ranking	-0.24	0.01
		QHEI	-0.23	0.02

IV. Vegetation Abundance

Metric	Hypothesized Change	Quality Measure	R ²	p
1. Average cover	Increase	Ranking	0.22	0.02
		QHEI	0.24	0.01
2. Relative abundance of exotics	Decrease	Ranking	-0.33	0.0006
		QHEI	-0.31	0.001

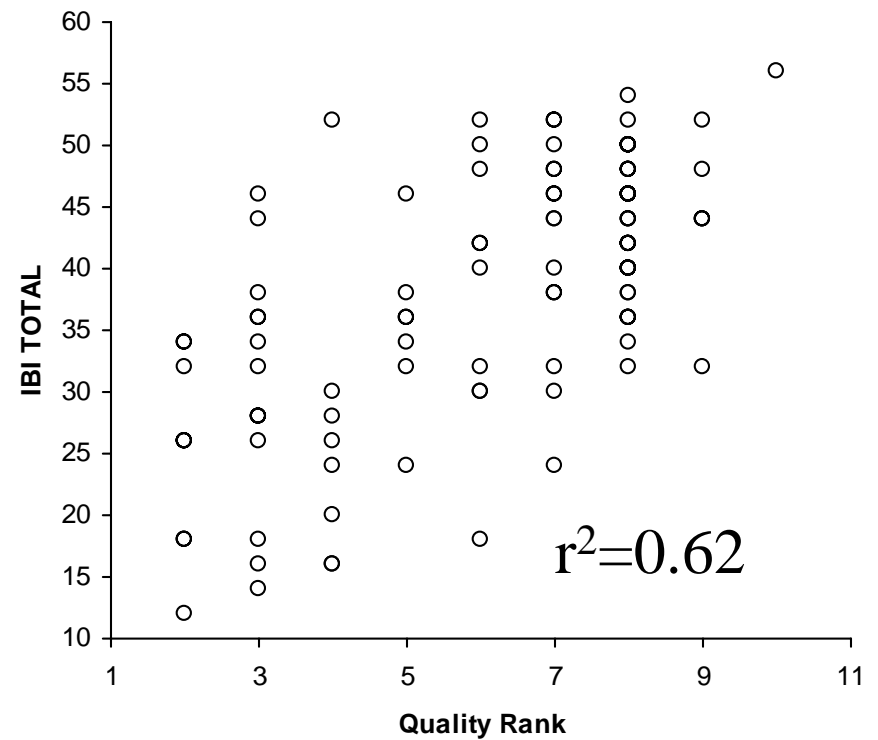
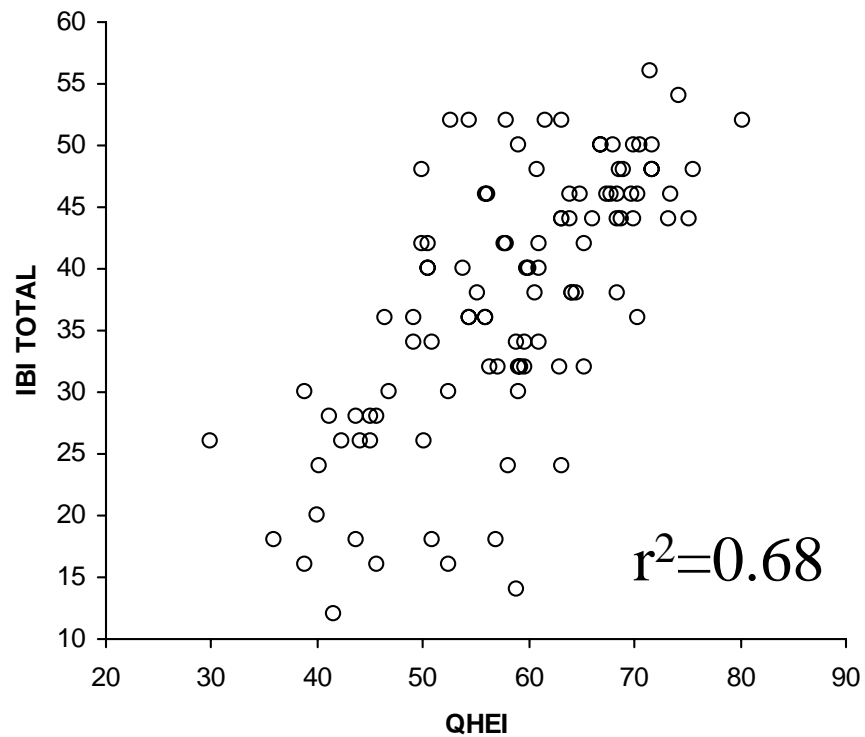
Metrics versus Lake Area



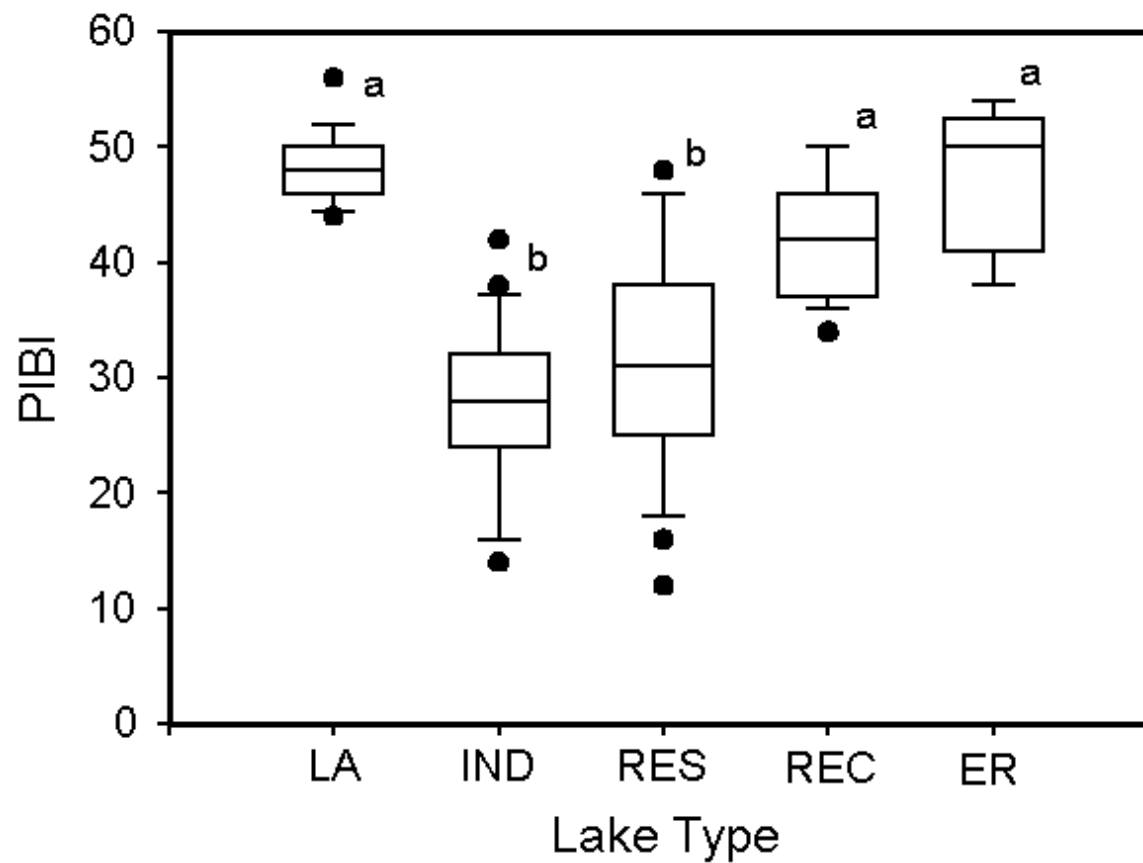
Total PIBI

Metric	Hypothesized Change	Quality Measure	R ²	p
Total PIBI	Increase	Ranking	0.62	<0.0001
		QHEI	0.68	<0.0001

QHEI/Quality Ranking versus PIBI



PIBI versus Lake Type



Fish Indicator Development



Objectives



- *Can a consistent standard operating procedure be developed for sampling lake littoral zones in Indiana?*
- Which attributes of fish community structure and function could be used to describe lake condition?
- What considerations should we be aware of for developing a Lake index of biotic integrity (IBI)?

Considerations

- Technique should be rapid (2-4 hrs max.);
- Two types of lakes occur in the northern Ecoregions (reservoirs & natural lakes);
- Littoral zones of lakes are the most productive and easiest sampled;
- Literature review and comparisons with other studies should build from what others have done;
- Zoogeography of system must determine expectations of community.

Background Information

- Indiana lakes have a legacy of study with some of the original limnological studies conducted on Lakes Wawasee, Crooked Lake, and Lake Maxinkuckee;
- Few studies have been conducted to evaluate sampling procedures and stratify sampling designs;
- Jennings et al. (1999) described approaches for sampling in Wisconsin, Whittier et al. (1995, 1997, 1999) evaluated procedures for Northeastern Lake study for EMAP;

Characteristics of natural lakes in Northern and Central Indiana

- Shallow to moderate (mean depths < 20 m);
- Lakes typically do not stratify in CCBP;
- Lake Michigan lakes heavily impacted due to filling of wetlands at turn of the century;
- Kankakee Lakes heavily managed for sport fishing;
- Eutrophic to hyper-eutrophic;
- Many lakes are individual and isolated.

Indiana Study Design

- Limited sampling to lakes > 20 hectares to avoid sampling farm ponds, borrow pits, and other artificial systems;
- Lakes selected for this study were randomly chosen based on equal distribution among three size classes small (20-100 ha), medium (100-1000 ha), and large (>1000 ha);
- Sampled lakes in four Ecoregions including the Eastern and Central Corn Belt Plain, Northern Indiana Till Plain, and Huron Erie Lake Plain.

Sampling Strategy



- Boat electrofishing was used so that we could put greater emphasis on getting a representative sample;
- Sampling conducted for 500 m & 1800 s;
- A select number of stations were indicated based on lake size;
- Targeted zones in natural shoreline areas otherwise found a consistent type of community;

Data Targets



- A total of 109 lakes were sampled in the four Ecoregions;
- 350 sampling stations were collected to provide data for calibrating an index;
- Validation of the index was based on targeted data from sites ranging from degraded to least-impacted based on an ecological dose-response curve developed by Karr and Chu (1999).

Objectives



- Can a consistent standard operating procedure be developed for sampling lake littoral zones in Indiana?
- **Which attributes of fish community structure and function could be used to describe lake condition?**
- What considerations should we be aware of for developing a Lake index of biotic integrity (IBI)?

Lentic Water IBI's

- Jennings et al. (1995) developed an IBI for Tennessee River reservoirs;
- Simon (1998) developed an IBI for palustrine wetlands in southern Lake Michigan, while Simon & Stewart (1998) validated the index using the Grand Calumet Lagoons;
- Jennings et al (1999) evaluated a preliminary IBI for Wisconsin lakes;
- Whittier et al (1999) developed expectations for NE United States lakes;
- Lyons et al. (1999) developed a preliminary index for Mexican lakes.
- Simon et al. (2000) modified the palustrine index for small vernal ponds:

Attributes of a Good Lake Fish Community

- Diverse assemblage of native species;
- Include specialists for vegetated areas;
- Include benthic species that indicated good sediment quality;
- Provide a strong, balanced trophic food web;
- Healthy fish -- free of disease;
- Fish should be typical or representative of lakes.

Validation Procedure

- Divided data set into “least-impacted” (reference condition) and impaired lakes;
- Evaluated 42 attributes of lake fish communities to formulate index;
- Compared reference condition lakes in order to develop expectations
- Lake expectations based on surface area;
- Assessment of a lake based on multiple sampling sites ranging from 2-6 sites.

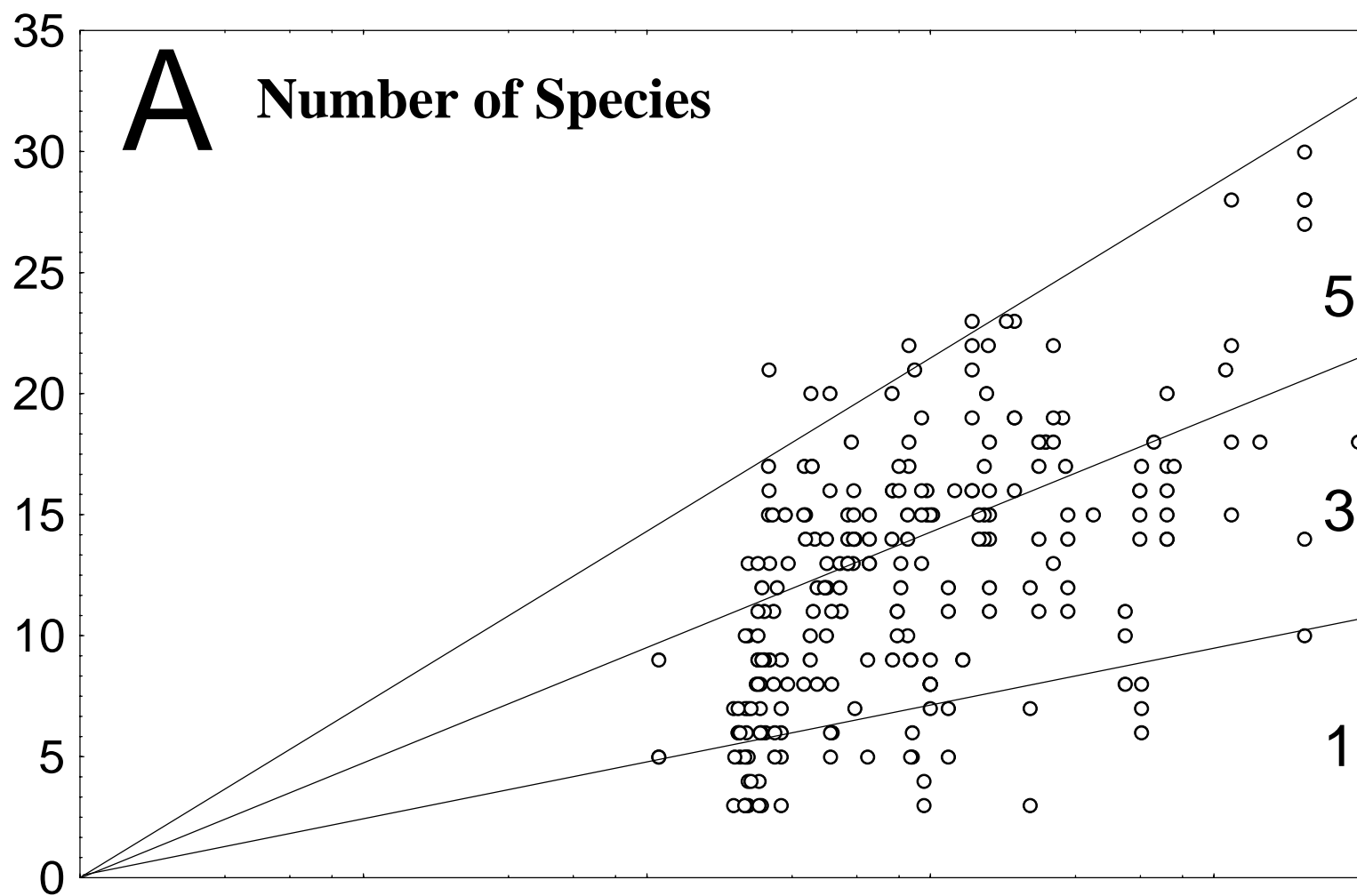
Metrics

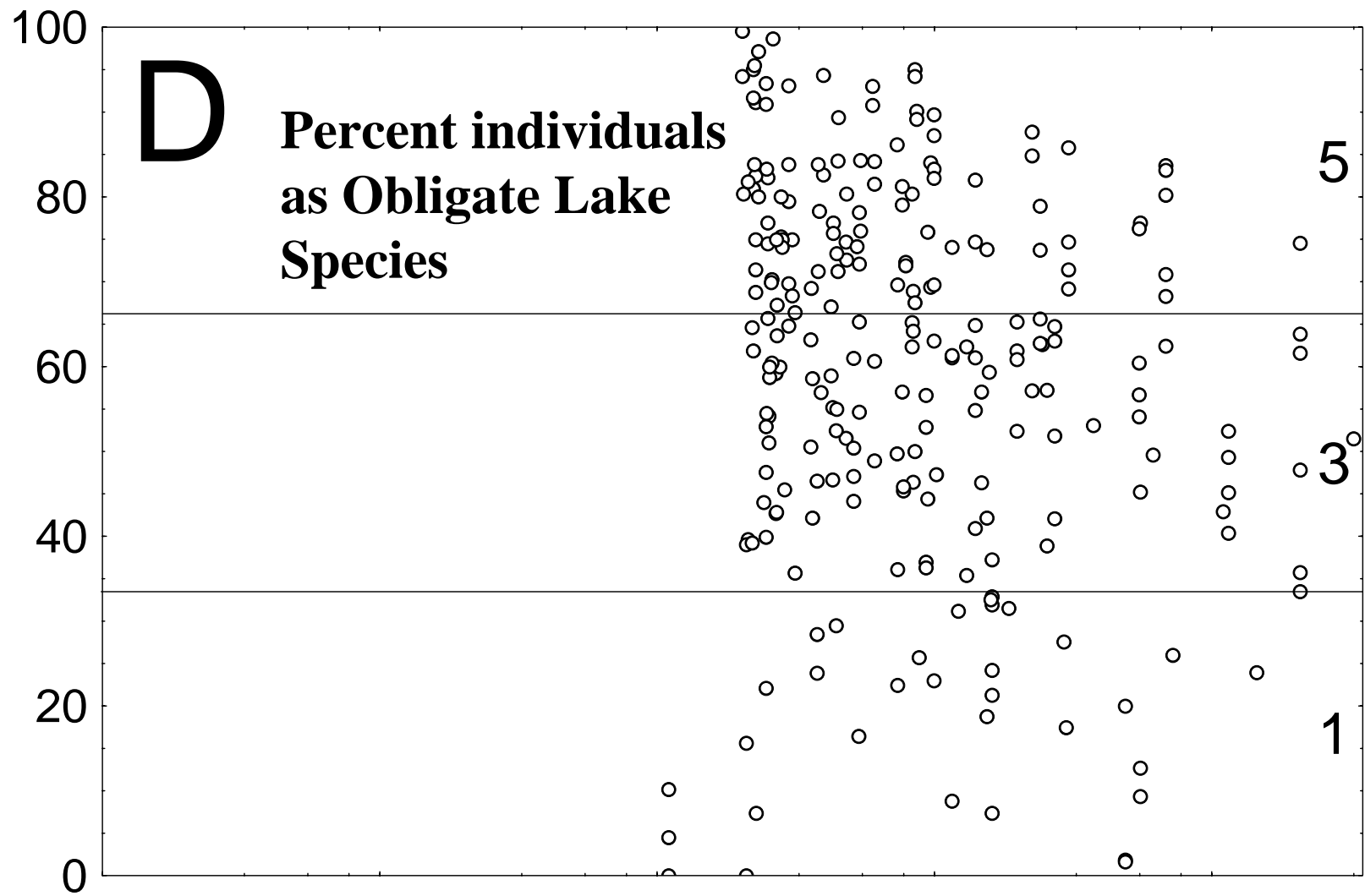


- ***Species Composition***: Number of native species; number of sunfish species; number of benthic specialists; number of lake obligate species;
- ***Sensitive/Tolerance***: Number of sensitive species; percent tolerant species
- ***Balanced trophic guilds***: percent detritivores, percent invertivores, percent top carnivores;
- ***Abundance and condition***: relative abundance; percent simple lithophils; percent DELT anomalies.

A

Number of Species





Objectives



- Can a consistent standard operating procedure be developed for sampling lake littoral zones in Indiana?
- Which attributes of fish community structure and function could be used to describe lake condition?
- *What considerations should we be aware of for developing a Lake index of biotic integrity (IBI) for the State of Indiana?*

Future Considerations

- Need to calibrate index for southern ecoregions (i.e., IRL and IP);
- Determine whether standard collection procedures will work for other lake types;
- Calibrate index for alternate lake types (i.e., natural, reservoir (riverine), oxbow);
- Determine further monitoring and assessment needs in order to facilitate condition determination.



Swamp Angel / Needham Lake Aug. 1999
(NE)